Impact of sudden mass mortality on suicides

Bertrand M. Roehner [1]

Institute for Theoretical and High Energy Physics, University of Paris 6

Abstract We show that a large scale mass mortality results in increased numbers of suicides. As a case in point, we consider the influenza epidemic of October 1918 in the United States. In this month, suicides peaked at a level of over 4σ (where σ denotes the desaisonalized standard deviation of the suicide rate) which means that one would expect such a jump to occur merely by chance only once in several centuries.

The mechanism that we propose to explain this effect relies on two steps (i) Mass mortalities break family bonds for instance between parents and children or husbands and wives. (ii) Increased numbers of suicides then result from the well known fact that the severance of family bonds invariably produces more suicides.

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1: LPTHE, 4 place Jussieu, F-75005 Paris, France.

E-mail: roehner@lpthe.jussieu.fr, Phone: 33 1 44 27 39 16

1 Basic observation

In this paper we show that a sudden mass mortality is followed within a few weeks by an upsurge of suicides.

What do we mean by the expression "sudden mass mortality"? "Sudden" refers to an event which occurs within one month or within a few months. "Mass mortality" refers to a monthly mortality rate which is at least twice the average rate.
For instance, in September 1918 there were 89,561 deaths in the United States which corresponds to a rate of $1.10/(\text{month} \times 1,000)$ whereas in October 1918 there were 329,400 deaths corresponding to a rate of $4.12/(\text{month} \times 1,000)$; in other words, as a result of the influenza epidemic, the death rate was multiplied by 3.7[1].

Table 1 US mortality data for 1918 and 1920 (per 1,000 persons)

	Influenza	Pneumonia and broncho-pneumonia	WWI deaths	All causes	Ratio to "normal" year
"Normal" year (1916)					
Annual death rate	0.26	1.38	0	14.0	
Average monthly death rate	0.02	0.11	0	1.17	
1918					
Annual death rate	2.80	2.74	0.95	18.7	**1.3**
Monthly death rate in Oct	1.44	0.94	0.57	4.12	**3.5**
1920					
Annual death rate	0.71	1.37	0	13.0	**0.93**
Monthly death rate in Feb	0.41	0.41	0	1.91	**1.6**

Notes: Strictly speaking, the data are for the Registration Area only not for the whole United States, but in 1916 the Registration Area comprised 71% of the total population and in 1920 this percentage was 88%. During the influenza epidemic the terminal cause of death was often diagnosed as being pneumonia or broncho-pneumonia; this is why these two causes must be taken into account as *directly* related to the influenza outbreak. Regarding the deaths of American soldiers in Europe, it should be recalled that almost all deaths occurred in 1918 and that about two-third of the 1918 fatalities occurred in October. February 1920 constituted a secondary peak in the influenza epidemic As expected, for mortality events which last only one or two months the ratio to a "normal year" is much higher for monthly than for annual data. In the latter case the extra-mortality is so-to-say spread and diluted over the whole year.
Sources: Mortality Statistics, volumes 1916, 1918, 1920; Clodfelter p. 785.

[1] All these data are taken from the annual volumes of the "Mortality Statistics" issued by the Department of Commerce and currently available online at the website of the "Centers of Disease Control and Prevention" (CDC). These figures in fact only refer to the part for which mortality data were collected (the so-called "Registration Area") which, in 1918, comprised 79% of the total population. We also added the deaths of US soldiers in Europe which, as all deaths occurring overseas) are not taken into account in the Mortality volumes.

What do we mean by an "upsurge of suicides"? To see this point more clearly we consider again the example of the United States. Between September and October 1918 the number of suicides increased 17% from 752 to 882. However, this increase can hardly be considered as convincing evidence of a possible effect of the influenza mortality. Indeed, jumps of this magnitude are fairly common. Just to give two examples: between February and March 1917 the number of suicides increased by 17% and between the same months of 1918 they increased by 12%. The reason behind the February to March increases is that suicides (more or less) follow a seasonal pattern with a minimum in December and a maximum in April or May.

So, is the jump which occurred from September to October 1918 completely spurious and irrelevant? Not so.

One obvious question is whether the seasonal pattern implies an increase or a decrease between September and October. Over the period 1910-1920 the average seasonal suicide pattern reveals a steady fall between May and December; altogether, the fall is about 22%. More specifically, between September and October the change is -3.6%[2]. In this light the 17% increase between September and October 1918 already becomes more significant. If one takes into account the seasonal pattern, the 17% change once adjusted becomes 23.6%. However, this does not yet allow us to conclude that this change is due to the mass mortality. It could be a purely random fluctuation.

To determine the degree of significance of this change in a more precise way, we need not only to compare the Sep-Oct jump in 1918 to the changes over the same months for other years (which is what we have done by using the seasonal pattern), we also need to know the variability of these changes. Depending on the magnitude of the standard deviation of these changes, the 1918 jump will appear more or less significant. This test was carried out for different areas. The results are summarized in table 2.
There are three points of interest in this table.

- Once expressed in terms of the standard deviation of the other October jumps, the jump Δ of October 1918 in the whole area is $\Delta = 4.6\sigma$; under the assumption of a Gaussian distribution[3], this means that in random drawings a fluctuation of such a size (or larger) will be observed once in 30,000 drawings (see table 3.2 in Roehner (2007). Henceforth, for the sake of brevity, the ratio Δ/σ will be called the σ-jump.
- One may wonder why the σ-jump of the whole area is so much larger than the σ-jumps of its urban and rural parts. The reason is very simple. Whereas the jump is

[2]On the contrary between February and May there is a 33% increase. More specifically, between February and March the increase is on average 23%.

[3]In Roehner (2007, p. 52-53) it was shown that the distribution of monthly suicide changes is indeed compatible with this assumption.

Table 2 How significant is the suicide jump of October 1918 in the United States

Area	Jump in Oct 1918 Δ	Average Oct. jumps over 1910-1920 (except 1918) m	Standard-deviation of jumps 1910-1920 (except 1918) σ	Seasonally adjusted jump $\Delta - m$	Jump expressed in terms of σ $(\Delta - m)/\sigma$	Ratio of extra-suicides to shock (per 1,000)
Cities	70	-7.1	33.4	77.1	**2.32**	0.60
Rural parts	55	-5.2	26.2	60.2	**2.29**	0.65
Total area	125	-12	30.1	137	**4.6**	0.62

Notes: October 1918 was the first month of the influenza epidemic. In most of the states it was during this month that the losses were largest. The total area under consideration corresponds to the so-called "Registration States". It comprised all states in which death statistics were duly recorded. Note that considering monthly changes (rather than monthly numbers) makes this analysis independent of possible trend modifications (which may be due to changes in the number of registration states or other slowly changing factors).
The meaning of "per 1,000" in the last column is that an extra-mortality of 100,000 deaths in a given month will result in $100 \times x$ additional suicides in that month, where x denotes the numbers in the last column. Thus, for cities, 100,000 extra-deaths will result in 60 additional suicides.
The statistical error bar on $(\Delta - m)/\sigma$ comes mainly from the confidence interval on the estimates of m and is therefore of the order of $1.96/\sqrt{10} = 0.6$ (for a probability level of 0.95).
Sources: The primary mortality data are taken from the annual volumes of "Mortality Statistics" published by the US Department of Commerce.

about twice as high (which is quite natural for an area which is twice as large) the σ of the total area is *not* twice as high. Why is this so? By listing the individual changes one is lead to the observation that most urban and rural changes are of comparable magnitude but of opposite sign[4]. Thus, by adding the two series one is led to a sum with a reduced standard deviation.
By generalizing this observation, one is led to a technique through which it becomes possible to increase the signal/noise ratio; it will be developed in a subsequent paper.

- As a rule of thumb one should retain that 100,000 extra-deaths lead to about 60 extra-suicides in the same month.

In order to show that these rules hold in a general way, one must of course present more than one case. We began with the example of the United States in October 1918 because of the conjunction of two favorable circumstances: (i) A large shock (ii) The existence of detailed statistics which are readily available through the Internet. We will shortly present other cases which display the same effect but before doing that we will explain the mechanism which may account for this effect.

[4]This is confirmed by the fact that the cross-correlation of the urban and rural series is -0.51.

2 How can one explain this effect?

There are very few characteristics of suicide which can be observed in a fairly universal way that is to say in all countries and in all times[5]. One of the most important is the fact that the suicide rates of married people are lower than the suicide rates of bachelors, widows or divorced people. This has been observed in all countries for which there are reliable data, and over all times from the 19th century to nowadays. This rule was already well-known by Emile Durkheim (1897); a summary of data with a broad coverage in space and time can be found in Roehner (2006, p. 257)[6]. This rule can be seen as expressing an equilibrium property. Here, however, we want to consider the non-equilibrium situation. For the sake of argument let us consider the specific case of widowers. Before they became widowers these people had a suicide rate of, say, 10 per 100,000. Once they have lost their wives their suicide rate jumps to about 25 per 10^5. Of course, one would like to know what is the time-constant τ of the transition from one state to another. Is it a few months or a few years? To answer this question in a reliable way one would need detailed data giving the dates of the widowhood and suicide events with an accuracy of a few weeks.

Anyway, whatever the precise answer to this question, one can be sure that the sudden death of 100,000 wives will lead (sooner or later) to the suicide of a certain number of widowers which would not have occurred if those wives had not died. These suicides will make up a part of the extra-suicides estimated above.

So far we have considered the marital bond. This is only one part of the story, however. Durkheim (1897, p. 59-62) has shown that for married people the suicide rate is strongly dependent upon the size of the family. According to results based on the census of 1886, the suicide rate drops eight-fold from 40 to 5 per 10^5 when the number of children increases (less than two-fold) from 1.4 to 2.3[7]. Now, if we use the same argument as previously, it can be seen that the sudden death of 100,000 children will lead (sooner or later) to the suicide of a certain number of their parents which would not have occurred if the children had not died. These suicides will make up another part of the extra-suicides.

If this mechanism is accepted at least as a working hypothesis there is an important implication. The fact that a significant number of extra-suicides occurred in the *same*

[5]For instance one can mention the following facts. Male suicide rates are higher than rates for females in western countries whereas in China and in some parts of India it is the opposite. Around 1890 in the time of Emile Durkheim suicide rates were generally higher in cities whereas it the opposite nowadays (e.g. the suicide rate in Arizona is about twice the rate in New York City).

[6]It is important to observe that the rule holds in each age-group and therefore cannot be attributed to age differences, e.g. widowers are on average older than married people.

[7]Such a strong relationship would certainly warrant additional investigation. Unfortunately, few sources give the number of children of the persons who commit suicide.

month as the mass mortality (namely in October 1918) implies that the time constant τ is of the order of a few weeks rather than a few months or a few years. Surprising as it may seem, this fact is indeed supported by evidence collected by researchers who were able to collect data for the delay between widowhood and suicide events (see Appendix A).

3 Conclusion

The effect studied in this paper is fairly weak. It became clearly observable only because we carefuly selected the conditions of observation. We concentrated our attention on the impact of the influenza epidemic of 1918 in the United States. This choice was dictated by two reasons: (i) This impact was particularly strong (ii) Detailed monthly statistics are available in this case which put us in a favorable position for carrying out all required statistical tests.

Of course, to validate our present finding it is essential to show that it holds as well for other countries and for other mass mortalities. This will be done in a subsequent paper.

Broadly speaking, we will use the following strategy. In the 19th century there were many epidemics which brought about substantial increases in mortality. Moreover, the recording (and publication) of reliable death statistics began around 1850 which means that for several countries (e.g. France, the German States, the Scandinavian countries) it is possible to find the *monthly* suicide data that are necessary for this analysis. Naturally, apart from epidemics there are also other causes of mortality that may provide good testing opportunities, e.g. the Tokyo-Kanto earthquake of 1923. In all these cases the first step (and indeed the main challenge) is to get reliable monthly data, possibly at regional level.

A Appendix: The timing of suicides after the disappearance of a link

A crucial question for the present problem is the delay between the rupture of a link and the ensuing suicide. To our best knowledge there are very few papers on this issue. One of the clearest investigations has been conducted by J. Bojanovsky (1979, 1980) in Germany. He followed the following procedure.

- For the cities of Heidelberg, Ludwigshaffen and Mannheim he was able to get police reports of suicides that occurred between 1971 and 1975. These reports gave the names and marital situation of the suicides.
- The names of all persons who were widowed or divorced at the time of suicide were recorded. To make the subsequent work simpler, only persons born in Germany were retained.
- For almost all these persons the investigators were able to obtain the dates of the widowhood or suicide from the official authorities of the "Land".

The results are given in Table A1.

Table A1 What is the delay between removal of the marital bond and suicide?

Delay between dissociation and suicide (month)	$0-6$	$7-12$	$13-24$	$25-60$	$61-120$
Duration of the time interval expressed in semesters	1	1	2	6	10
Actual numbers					
Widowhood, males (43 cases)	17	3	8	8	7
Divorce, males (55 cases)	17	5	10	19	4
Widowhood, females (56 cases)	9	5	10	12	20
Divorce, females (27 cases)	1	1	7	10	8
					1
Rates (per month and per 100 suicides)					
Widowhood, males	40%	7%	9%	3%	1.6%
Divorce, males	31%	9%	9%	6%	0.7%
Widowhood, females	16%	9%	9%	3%	3%
Divorce, females	3.7%	3.7%	13%	6%	3%

Notes: The figures within parenthesis in the first column give the size of the sample. It can be seen that for widowers the rate in the first semester is about 6 times higher than in the second semester or in the second year. It would be interesting to have detailed monthly data for the first semester but this would require samples at least 10 times larger. For females, the concentration of the suicides on the first semester after dissociation is much smaller. This is not surprising on account of the known fact that females are less affected than males by a rupture of the marital bond. The size of the samples given in the first part of the table shows that one cannot expect too much precision from this investigation.
Sources: Bojanovsky (1979, p. 75, 1980, p. 101).

As is well-known widowed or divorced women are much less prone to suicide than

men, so we should concentrate our attention on the results for males. Furthermore, for the purpose of the present paper we are interested in widowhood rather than in divorce.
It can be seen that for widowers the number of suicides that occurred in the first semester after the death of the wife was 5.7 times larger than during the second semester and 4.4 times larger than during each of the semesters of the second year. In other words, the effect of a large-scale disappearance of wives would become almost unobservable after the first semester. Naturally, for the present investigation one would like to know the distribution of suicides over the successive months of the first semester, but this would clearly require a much larger sample. On account of the results in the present paper one would predict that this distribution has a peak in the first month from which it decreases steadily.

From Bojanovsky's results it can be predicted that almost all the extra suicides in October 1918 which came after widowhood were committed by men. Let us go a step further and assume that males are also more affected than females after the loss of a child (on this point we have no solid indications so far). Under such assumptions it is possible to derive a prediction which may be tested.
In 1914, 1915, 1916 the ratios of male to female suicides were: 3.30, 3.35 and 3.35 respectively (Historical Statistics of the United States 1975, p. 414). In 1917, 1918, 1919, for some unknown reason, the ratio fell to 3.02, 2.93 and 2.71 respectively. The extra-suicides in October 1918 (with respect to September) numbered $882 - 752 = 130$. Unfortunately, the 1918 volume of "Mortality Statistics" does not give monthly suicide numbers by gender. So one must make some assumptions in order to proceed.
If, for the sake of simplicity, we assume that the gender-ratios in September and October were identical for the 752 "normal" suicides (we denote it by r) and that all 130 extra-suicides were committed by men, then a simple calculation shows that the gender-ratio in October should be:

$$r' = \frac{752/(1+1/r)+130}{752/(1+r)} = r + \frac{130}{752}(1+r)$$

For instance, if $r = 2.93$ one gets: $r' = 3.60$. Such a change of 23% is sufficiently large to be observable. In other words, it should be possible to check this prediction when detailed data become available.

References

Bojanovsky (J.) 1979: Wann droht der Selbstmord bei Geschiedenen? [When after a divorce is the likelihood of committing suicide largest?]. Schweizer Archiv für Neurologie, Neurochirurgie und Psychiatrie 125,1,73-78.

Bojanovsky (J.) 1980: Wann droht der Selbstmord bei Verwitweten? [When after becoming a widower is the likelihood of committing suicide largest?]. Schweizer Archiv für Neurologie, Neurochirurgie und Psychiatrie 127,1,99-103.

Durkheim (E.) 1897: Le suicide: étude de sociologie. Félix Alcan, Paris.
[An English translation appeared in 1951 under the title: “Suicide, a study in sociology”, Free Press, Glencoe (Illinois)].

Clodfelter (M.) 1992: Warfare and armed conflicts. A statistical reference to casualty and other figures 1618-1991. (2 volumes). McFarland and Company, Jefferson (North Carolina).

Roehner (B.M.) 2007: Driving forces in physical, biological, and socio-economic phenomena. A network science investigation of social bonds and interactions. Cambridge University Press, Cambridge (UK).

Roehner (B.M.) 2008: Econophysics: challenges and promises. An observation-based approach. Evolutionary and Institutional Economic Review 4,2,251-266.